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Energy At The Sawmill: Conservation And Cost Reduction

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Energy today is plentiful and cheap. But we should be good stewards of our energy resources, just as we provide for wise management and use of our natural forest resources. This paper examines energy usage patterns as they relate to the individual components of an industrial electric utility bill. With this understanding, more than 75 economical ways to reduce energy consumption and electric bills are presented – ways to save money without affecting production. Potential savings come from direct employee heating; efficient use of lighting, electrical motors and compressors; sawing improvements; and the efficient operation of boilers and dry kilns.

The Facts

Let's start our examination of energy use in the sawmill by considering the following facts:

- In North America today, energy is often too cheap to save.
- In North America today, we waste large amounts of energy.
- Sawmills are nearly all equally energy inefficient.
- Energy costs are a minor component of the cost of finished lumber products. This means that an energy savings in lumber manufacturing will have less impact on our operation than a similar savings for other industries.
- The potential for energy savings in an existing mill is severely limited.
- Lumber is a "low energy to manufacture" product when compared to aluminum, steel and plastic. Rising energy prices will not affect sawmill products as much as others.
- The forest products industry is often the largest energy user for utilities.
- Wood that can be made into lumber is too valuable to burn!

Why Save?

Next, consider why we are motivated to adopt energy savings in a mill. There are five basic reasons:

- Government edict; it is the law!
- Government payment; tax incentives!
- Concerns for the environment: pollution, greenhouse effect, etc.
- Concerns for the future; limited supplies of petroleum.
- Increase in the price of energy or decrease in the supply.

Why Waste?

Then, consider the most frequently given reasons for not conserving energy. There are five:

- It is too technical for present employees.
- It will require extra employees to implement.
- It is too expensive, especially if the competition doesn't do it.
- Payback is too long or too small.
- Energy costs are only a small component of operating costs. Yield and employee efficiency savings have larger impacts on profit.

How To Save

Finally, consider ways to conserve energy and reduce costs. There are two general approaches:

- Operate existing processes more efficiently.
- Adopt new, more energy efficient processes.

Both of these approaches would be ideal, but in the real world, they require capital and time expenditures. We need some truly affordable, simple ways of controlling our energy use. Before we can save energy, we must understand our energy use patterns and how we are charged for the energy we used.

UNDERSTANDING YOUR ENERGY USAGE

The first place to look for energy savings is in those items that use the most energy. In a typical sawmill, energy usage is divided between six processing categories, as shown in the data from a United Nations study.

Process	Usage
Sawing	36%
Material Handling	27%
Planing	18%
Sorting & Barking	8%
Chipping	8%
Miscellaneous	3%

In the typical sawmill (without kilns), sawing and material handling use the most energy and would be the first places to look for energy savings. For mills with kilns, the first place to look for energy savings is in drying. Kiln-drying uses 6 to 9 times more energy than the sawmilling operation itself.

The table above is a generalization. In your mill, the initial step in any energy savings program should be an energy audit. Audits indicate where energy is being used and at what rates, and which equipment and operations are determining your electrical demand. The audit should make clear which processing areas to target for reduced energy use.

It is also important to understand how you are being charged for the electricity your mill uses. This knowledge applied to the energy audit will direct you to high payback, energy saving ideas.

UNDERSTANDING TOUR ELECTRIC UTILITY BILL

One of the largest single checks written each month is to the utility company for electricity. Let's consider the various components of an electric bill. The examples will show that the true cost of lighting a light bulb or running an electric motor can be more than 3 times what you thought it was.

The Basic Components

There are three basic components of an industrial electric bill: customer charge, energy charge, and demand charge. (Some utilities also have a reactive demand, or reactive power, charge.) For this discussion, we will use a recent tariff schedule from Wisconsin Power & Light (WPL) for industries under 200 kilowatt (kW) demand. There are two rate plans: “Standard,” which would be appropriate for most operations running one or two shifts per day, and “Time of Day,” which would be appropriate for equipment that runs around the clock, such as kiln fans. We will consider an example using the standard rate.

Customer charge

The industrial customer service charge for WPL is $12.00/month.

Energy charge

Electrical power is determined by multiplying current (in amperes) by voltage (in volts). The resulting units are watts (W), 1000 watts equals 1 kilowatt (kW). A kilowatt is equal to 3414 Btu/hour, 0.012 boiler horsepower, or 1.34 electric horsepower.

Electrical energy use is measured in kilowatt hours (kWh). A 100-W light bulb (0.9 amperes x

110 volts) burning for one hour will use 0.1 kWh of electricity (100 watts x 1 hour ÷ 1000W/kWh).

The electric company uses a certain amount of fuel to produce every kilowatt of energy. Therefore, a part of their rate is a charge for energy consumption. Energy usage is measured with an electric meter identical to those for private residences. WPL charges $0.02758 per kWh – roughly 2-3/4 cents. At times, the utility might add a fuel surcharge to the base rate when the cost of fuel escalates quickly.

Demand charge

The electric company must be able to supply the total amount of energy that all its customers want when the customers want or 'demand' it. When we throw a switch "on," we expect to have enough current at the correct voltage. If the company cannot meet the customers' demand, a "brownout" results.

To meet the peak demand of its customers, the power company must design for it, even though 99.99% of the time their equipment will be working below capacity. In Wisconsin, the peak demand occurs on hot summer days, when air conditioners are running on full. Another component of the electric bill, then, incorporates the capital it takes to overbuild the power plant to handle the expected peak demand. It follows that any industry that has a high peak demand, especially if it peaks when everyone else's does, ought to pay more than an industry with less demand.

The total energy used at any one time - the demand - is expressed in kilowatts. The demand for one 100-W bulb burning for 1 hour is 0.1 kW. If it is on for 10 hours, the demand is still 0.1 kW, although the total energy used is ten times larger. At any one time, in other words, 0.1 kW are being used. Ten 100-W bulbs burning for one hour will use the same total energy as one 100-W bulb burning for 10 hours, but the demand for the ten bulbs is 1 kW.

The demand charge for the month is based on the 15-minute (30-minute for some utilities) period of the month with the highest demand. A demand meter can only go up. When it is read monthly, it is reset to zero. If, during one 15-minute period during the month, everything is turned on and running, the demand charge for the entire month is established, even if only half of the equipment runs the rest of the month. The monthly demand charge for WPL is $6.00 per peak kW demand during the month.

Many utilities have a minimum demand charge, so that, even if you have a low demand during one month, you are billed at the minimum rate. WPL builds its minimum charge into a "customer demand" charge of $1.00 per kW demanded during the peak 15-minute period of the past 12 months.

Reactive demand (reactive power) charge

The final component of some electric bills is a reactive power charge. WPL does not include this item in their bill. Reactive demand is a measure of the phase change that occurs with a motor and is related to the motor's power factor. The charge is usually quite small; but reactive power is wasted power. It does not help the motor deliver more power. But, because the reactive power charge is small, it is often too expensive to save this energy.

The Bill

Assume that a sawmill used 38,160 kWh in a month. They operated for 220 hours during the month, giving an average demand of 173 kW (38,160 kWh ÷ 220 hours). This is equivalent to ten 20-hp motors. The mill's peak demand for the month was 195 kW. and for the year, 198 kW. The monthly electric bill from WPL was:

Item	Amount
Customer charge	$12.00
Energy charge (38,160 x 0.02758)	$1094.68
Demand charge (195 x 6.00)	$1170.00
Customer demand (198 x 1.00)	$198.00
TOTAL	$2432.45

The bill represents the charges for using 38,160 kWh. The average charge is 6.37 cents per kWh, even though the basic tariff is only 2.75 cents per kWh! This illustrates the impact of the demand charge, and why further discussions on reducing demand are so important.

Alternate Rates

Many utilities offer alternative rate schedules. WPL, for example, offers a flat rate schedule. Electricity is charged at $0.08898/kWh, with no demand charge. The above example bill charged at this flat rate would be 40% higher. The utility will usually bill the industry the lower of the two rates, or let the industry choose their rate schedule in advance.

WPL also offers a "time of day" rate schedule, which is advantageous to industries which run equipment 24 hours per day, like kiln fans. The time of day schedule charges an "on peak" rate (8:00am to 10:00pm, Monday through Friday) of $0.03248/kwh, and an “off peak” rate of $0.02148/kWh. Consider a motor that uses 10 kWh, running 24 hours a day, seven days per week. WPL’s standard rate for one week would be $46.33 (10 kWh x 24 hrs/day x 7 days x $0.02758). However, the “Time of Day” cost would be only $43.79, a 5% savings. It is usually advantageous to have continually operating machinery on a separate meter with an off-peak rate.

SAVING ENERGY AND MONEY

Reducing Demand

Utility companies have developed many special rules concerning the demand charge. In one Southern utility, if you are willing to close down by 12:30pm every day in June through September (the peak air conditioning hours), they will reduce your bill by 50 percent or more. If you are able to reduce your energy consumption, but not your demand, you save only the 2-3/4 cents per unused kilowatt hour.

Consider two plausible examples:

Example 1

Ten 100-W light bulbs are used for security lighting. They are on 24 hours a day, 30 days a month. The monthly power usage would be 720 kWh (10 bulbs x .1kW/bulb x 24 hours/day x 30 days). The demand is 1 kW (10 bulbs x .1kW/bulb). The energy cost is $19.86/month (720 kWh x $0.02758), and the demand charge is $6.00/month (1 kW/month x $6.00/kW). The cost of running the bulbs, then, is $25.86 per month ($19.86 + $6.00).

Now, consider that the bulbs are turned off in the morning, at least 15 minutes before the mill is started, and then turned on again in the evening, at least 15 minutes after the mill is shut down. In other words, the bulbs will not contribute to the demand charge. Further, the bulbs are run only 12 hours a day. The cost of running the bulbs is now $9.93 per month for the electricity, with no demand charge. Shutting these ten bulbs off during the day saved $15.93 a month! Of course, if you forget to shut them off just one day, they will boost the month’s demand charge by $6.00.

Example 2

There are two pieces of machinery. Each uses 50 kWh of energy and has a 50 kW demand (roughly 60 hp). We typically run both machines 8 hours a day. If we could shut off one of the machines for 4 hours every day, we could save $5.52 per day (50 kWh x $0.02758 x 4) – over $120 per month.

If we can also arrange it so that the two machines are NEVER on at the same time, the demand charges will be cut in half. This can be done by turning machines off when they are not in use. For example, run 4 hours worth of lumber through the planer. Then turn off the planer and run the wood through the molder. The savings would be $300 in demand charges every month (50 kW x $6.00/kW).

It should be obvious from these examples and the preceding discussion that monitoring the demand of a mill can be very cost-rewarding. You can purchase a demand warning alarm that lets you set a maximum demand level. (See your utility company for a list of recommended manufacturers.) If your demand approaches the limit, an alarm sounds, and perhaps, some machines are automatically shut down. For a larger electricity user, computerized energy monitoring and management systems are available and are usually worth the expense.

Energy Conservation and Cost Reduction

Being aware of the ways in which your mill is using energy, and knowing how usage patterns can drive up the bill, gives you the basic tools for conserving energy and reducing your costs. Now let's look at each of the major energy use areas in your mill, and put these tools to work

Energy conservation and cost reduction can be tied to seven major energy areas in the sawmill. These areas are space heaters, lights, electric motors, compressors, saws, boilers and dryers.

The first and most cost-effective step for saving energy is to contact your power company for an energy audit. This is a free service. Make sure you explore all the possible tariff schedules available. There might be a better tariff than you are currently charged. One very good idea is to put the office complex on its own electric meter, separate from the mill. This removes the office from the mill’s demand factor and usually saves money.

Remember, when you first begin and energy savings program, that the first steps towards conserving energy are usually quite easy and cost effective. As the energy program grows, however, savings are often more difficult to realize and less cost effective.

Conserving energy and reducing costs do not need to involve the time and talents of a technologist; nor do they need to be part of a capital expenditure program. All they require is a little knowledge. With this in mind, we can go through an array of suggestions for keeping electric costs down in every part of the mill.

Heating (and cooling)

Our first concern in employee heating is performance; a cold employee is not a safe or efficient employee. But, if we can save on heating without affecting performance, let's do it!

The small 1- to 5-kW space heaters often used in the office and on the shop floor on cold mornings are very expensive. Although the power they use only costs $0.03 or $0.14 per hour (respectively), they add $6.00 or $30.00 to the demand for the month. To save on heating costs, let's first consider what it takes to keep someone warm.

Our bodies and clothing constantly lose heat by radiating energy to our surroundings. To control workers' comfort, heat losses from the body must be controlled. We do this by heating the work area.

In a large space, like that in a mill, heating the entire space is inefficient. Therefore, we use a spot heater--a very hot radiant heater (1000°F or more)--or a convective heater, which blows warm air. With either type of heater, employees are heated, but so are other nearby things in the mill. Efficiency is further reduced if the heated area is not effectively sealed from the cold, outside air.

Because the body loses as much as one-fourth of its heat from the head, and the amount of heat being lost determines a person's comfort, employees will feel comfortable at a cooler temperature if they are wearing warm caps.

It should be noted that the changes in temperature which are critical for employee comfort have little effect on wood. Wood does not change its properties, or shrink or swell, with these moderate changes. Between 30 and 150^{O}F, wood shrinks and swells only when the relative humidity changes. So, when heating for employee warmth, do not be concerned about the wood, only the employees.

Several techniques for saving energy in heating (and cooling) are applicable to the sawmill.

1. If convective heating is used, apply several inches of building insulation on the walls and roof. Be sure to block off leaks around windows, doors and vents. Turn, the thermostat down shortly before work ends.

2. Reduce air conditioning loads by proper maintenance. Keep filters clean. Turn a/c systems off shortly before work ends.

3. Seal off areas that do not need to be heated or air conditioned, and avoid overheating work areas.

4. Use radiation beaters to heat individual work stations when employees are spread out over a large area, rather than trying to heat the entire area with convection heaters.

5. Encourage employees to wear warm clothing, especially hats, to reduce their heating needs.

6. Turn up the office thermostat if the office heater is gas or oil. This is cheaper than using small electric heaters or foot warmers.

Lighting

Safety, as influenced by adequate lighting, is of utmost concern when considering lighting and energy conservation. Because 70% of the cost of lighting an area is for electricity (30% is capital expense and maintenance), the efficient use of the light produced is essential. Lighting should be sufficient for the area, but not excessive.

Different lighting systems have different efficiencies--their efficiency is a measure of the amount of power used for the amount of light produced.

Lighting	Efficiency
Incandescent	10%
Fluorescent	20%
Mercury vapor	24%
Sodium halide	33%

In addition to the inherent inefficiency shown in the table above, the output of lights drops with the age of the bulbs and with increased operating temperatures. With fluorescent bulbs, for example, if the output is 100% at or below 80°F, it drops to 80% at 115°F and 75% at 130°F.

The following suggestions apply to most types of bulbs and lighting situations:

1. Replace bulbs when they reach their specified service life, rather than waiting for them to burn out. This assures high efficiency.

2. Keep air temperatures around the bulbs as cool as possible. Avoid installing lights in a poorly vented enclosure.

3. Use a reflector to direct the light only to where the light is needed, and keep reflector surfaces clean. A thin layer of dust can reduce reflectance by 15%!

4. Take advantage of natural light. Lights near windows should have separate switches so the lights can be shut off on sunny days.

5. Paint walls a light color for maximum reflectance.

6. Color-code switches to indicate when to turn on and off. For example, red switches are turned on at night and off in the morning; blue are turned off at the end of the day.

7. Turn off lights if they will not be needed within the next 5 minutes.

Electric motors

The efficient use of electricity for electric motors can help to control energy bills without compromising the motors' effectiveness. The ideas for conserving energy are technically sound; you must assess the economic feasibility for your operation.

1. Always design and operate a motor at full load; do not oversize a motor.

2. Use higher voltages for motors; higher voltages mean smaller motors (physically) with less heat loss and greater efficiency--220 volts is better than 110; 440 better than 220.

3. Improve the motors' power factors with capacitors (if your utility has a reactive demand charge).

4. Measure your mill's demand with a recording demand meter to see when the peak occurs.

5. Keep motors working; if they are frequently idle for brief periods throughout the day, try to replace them with smaller, slower motors. A smaller motor running full-time uses less electricity than a larger motor running periodically.

6. Shut off electric motors if they will be idle for longer than ½ hour; the energy used to restart exceeds the energy used in ½ hour.

7. Put any motor that runs for 24 hours a day on a separate electrical meter to receive a lower rate and demand charge.

8. Consider running some operations only on weekends; you may get a lower rate.

9. Use "homemade" energy if possible to reduce purchased electricity consumption. This is especially attractive if you have kilns or other equipment which runs 24 hours a day.

10. Use alternate energy sources or generate a portion of electricity "in house" at peak demand time to reduce demand.

Compressors

The most inefficient use of electrical energy is in compressing air. Pneumatic conveyors are cheaper to install, but use 10 to 20 times more energy than electrical conveyors. Substantial savings can be achieved by improving the air system, including the compressors.

1. Use lower-pressure air, it is much cheaper than higher-pressure.

2. Use several small compressors rather than one big one. The energy used by a large compressor under full load is about the same as under a partial load. With several small compressors, some can be shut off at certain times, allowing for energy savings. Use small compressors for kiln operations. A small compressor for each kiln, for example, is more efficient than one large one; individual compressors can be shut off when the kiln is off.

3. Draw intake air from the outside, especially in cooler climates. Each 7°F rise in temperature requires 1% more energy to compress the air.

4. Keep intake filters free of dirt. Each 1% drop in pressure at the intake results in a loss of nearly 1% in efficiency.

5. Try to recover the heat from compressors, especially large ones. Blow the hot air to a location that needs heat.

6. Shut off the compressor when the machine(s) that it services is shut down.

7. Repair air leaks; they are very costly.

8. Avoid automatic condensate drains, or blow-downs; they can waste energy by blowing too often, especially in the winter. In general, a compressor requires less blow-down in winter because the air is drier than in summer.

Sawing

There are only a few opportunities for saving energy in sawing, and only if the following ideas result in the ability to use a smaller motor. If the motor is not changed, there will be minimal savings.

1. Keep teeth and blades as sharp as possible; dirty logs and inadequate debarking dull teeth prematurely.

2. Don't skimp on clearance angles; small clearance means rubbing, heat and wasted energy.

3. Use a thinner kerf. Don't over-swage. Consider opportunities to use Stellite™ teeth.

4. Take an adequate bite with each tooth. Feeding too slowly increases energy use. Reducing the number of saw teeth will utilize the capacity of each tooth more completely.

5. Defrost frozen logs if the energy used doesn't cost more than the benefit of sawing unfrozen logs. If possible, use otherwise-wasted heat from steam blown-down or flash steam.

6. Use proper lubricants. Lubricate regularly.

7. Use direct drive where possible instead of gears and belts.

Boilers

It is common in our industry to hear that burning wood is inexpensive. That can be true if the boiler consumes wood waste. Boiler disposal can be cheaper and more environmentally sound than hauling the wood to the dump or to the pulp mill. In most operations, however, there is a significant, although sometimes hidden, cost to burning wood.

Boiler and dry kiln operations are not highly efficient. Each pound of water evaporated in the dry kiln requires two pounds of water converted to steam in the boiler. If hot air rather than steam is needed, consider heating air directly with a burner and a flue-gas heat exchanger.

Energy savings in wood-fired boilers, or in the processes they provide steam for, especially drying, will save wood. Savings that can, in turn, allow for better heating in cooler months, or the development of a fuel surplus. In a mill that is short on capital, a more efficient boiler or energy, using process can stave off the purchase of a new boiler.

There are many practical, easy-to-implement, energy-saving ways to improve boiler efficiency:

1. Keep rain and snow off of wood fuel. Each pound of water (1 pint) absorbed by the fuel reduces energy output by 1000 Btu's or more,

2. Use the most efficient boiler possible, even if it costs a little more for the equipment. A boiler will consume 10 times its capital cost in fuel during 1 year of operation. A more efficient boiler will pay for itself in a year or less.

3. Do not oversize a boiler; heat losses go up as boiler size increases.

4. Use a large boiler to provide routine steam needs and a small, part-time boiler to supply the extra steam needed for peak demands - especially if steam demand is cyclical.

5. Provide enough air to achieve complete combustion and reduce pollution. Monitor exhaust gas composition (especially the carbon monoxide and carbon dioxide levels) to assure that the air to fuel ratio is optimum.

6. Clean burner surfaces (both the heat side and the water side) to assure good heat transfer.

7. Keep fans, dampers, insulation, and brick work in good repair.

8. Keep condensate tanks insulated. Roughly 25% of the energy in a boiler is lost in the condensate. A 10°F loss in condensate temperature is a 1% energy loss.

9. Preheat the boiler makeup water using energy that would otherwise be wasted (heat from compressors or dry kiln vents, for example).

10. Preheat Bunker C fuel oil with waste heat.

11. Keep wood-fired boilers as close to full load capacity as possible; the closer to capacity, the cheaper the energy produced.

12. Avoid excessive blow-down.

13. Explore the opportunities to recover some heat from stack gases.

14. Repair steam leaks immediately. The loss of 1 pound of steam wastes enough energy to heat 1000 cubic feet of air from 70 to 180°F.

15. Install a steam engine or steam turbine to run a generator, compressor, or chipper.

Dry kilns

The dry kiln uses 6 to 9 times more energy than the rest of the sawmill. Oftentimes, dry kilns are the most energy inefficient part of the sawmill. In the kiln drying operation, the cost of energy - both heat and electrical - is larger than the material handling costs. It follows that the greatest energy saving opportunities are in the kiln area. Energy use patterns in a kiln can be calculated using a computer program available free from the author.

Energy is lost as heat through convection: heat escapes through poorly insulated walls, floors and roofs; through improperly sealed doors and joints; and through the ventilation system, Oversized, out-of-repair and overused -motors use excess electricity.

The following energy-saving ideas generally apply to all kilns and all species:

1. Use as much air drying as possible to reduce the amount of water that must be evaporated in the kiln. Three days of good air drying can, reduce the evaporation energy by 20%.

2. Keep large roofs over drying piles to prevent wetting by rain. Sheds are often worthwhile.

3. Doubling the insulation in the walls, floor and roof will cut conduction losses in half, saving about 93,000 Btu's per MBF, or roughly $1500 annually. This is only economical if the insulation can be doubled for $3000.

4. Repair all holes, cracks and leaks in the kiln structure and kiln doors, especially at wall and roof panel joints.

5. Check door seals. Tightly seal any holes in the doors where the tracks fit. Keep door gaskets in good repair.

6. Coat interior, non-aluminum kiln walls with a vapor-proof sealer. Only the joints of aluminum walls need sealing. Sealing prevents moisture in the kiln from moving into walls and destroying the insulation's properties.

7. Do not paint exterior masonry walls as paint can trap moisture in the walls. Paint exterior aluminum walls a dark color to raise solar heating and reduce conduction losses.

8. Check that all wall and roof panels have drainage holes (weep holes) to allow drainage of condensed water from inside the walls.

9. Check roof maintenance frequently. Often the insulation gets wet, leading to poor insulating qualities, corrosion and deterioration.

10. Keep the steam system in proper working order - fix leaks and maintain traps, check valves and return pumps.

11. Free heating coils of debris and corrosion. Corroded pipes indicate the operating temperature is too low - look for water in the coils, excessive number of coils, or coil blockage.

12. Make sure valves and vents close tightly.

13. Install a heat exchanger on the vents.

14. Check kiln control calibration. Most controls will maintain calibration for several years.

15. Baffle the kiln well, including floor, roof and end baffles. Baffle gaps between packages.

16. Load the kiln to its rated or designed capacity. When purchasing new kilns, several smaller kilns may be more efficient that a large one.

17. Avoid low wet-bulbs or low EMCs on warm, humid days.

18. Use advanced schedules for kilns.

19. Do not use steam or water spray in the kiln except for conditioning, the water released from the lumber each day is usually sufficient to keep the humidity at desired levels.

20. Reverse fans every 6 hours when under 30% MC.

21. Reduce fan speed when lumber is below 20% MC, when drying rate is no longer determined by the speed at which air carries moisture away. Energy saved with a 20% fan speed reduction is about 50%.

22. Avoid overdrying lumber. Make kiln loads as uniform as possible (in initial moisture content, lumber size, species composition. etc.). Accurately monitor MC during drying.

23. Do not over-condition.

24. Unload and reload the kiln as fast as possible.

CONCLUSION

Although today, energy is often too cheap to save, the sawmill industry has always been a leader in the wise use of our natural resources. Many the opportunities for saving energy in the mill require very little investment and have very good paybacks. Some of the best, opportunities are available when new equipment is designed and installed. The place to begin your energy conservation program is with a free audit from your utility company, including an analysis of your energy use patterns and your monthly electric bill.

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